

## Original Research Article

# Locking plate for displaced proximal humerus fractures-outcomes and complications: a prospective study

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**Received:** 19 August 2019

**Revised:** 15 October 2019

**Accepted:** 17 October 2019

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### ABSTRACT

**Background:** The management of unstable proximal humerus fractures is controversial as many fixation techniques have evolved over the years claiming to be a better fixation device compared to the other.

**Methods:** 23 patients with closed displaced proximal humerus fractures were included in this study. All patients underwent open reduction and internal fixation with proximal humerus locking plate through either delto-pectoral or deltoid splitting approach. Standard shoulder rehabilitation program was used in all cases. Functional and radiological outcome were assessed at follow-up.

**Results:** The mean constant-Murley score achieved at 6 months was 66. Complications were reported in a total of 7 patients including 3 varus malunion, 1 valgus malunion, 2 screw penetration into the joint and 1 nonunion with implant breakage.

**Conclusions:** The proximal humeral locking plate seems to be an adequate device for the fixation of displaced proximal humerus fractures as 83% of our study population had good/moderate functional outcomes.

**Keywords:** Humerus, Treatment outcome, Fracture fixation

### INTRODUCTION

The incidence of trauma related skeletal injuries have been on the rise in recent years and proximal humeral fractures alone account for approximately 4 to 5% of all bony injuries.<sup>1</sup> Multiple factors related to patient, surgeon and fixation technique govern the outcomes of these injuries. Though locking plate technology was recommended for fixing proximal humeral fracture there are varied reports regarding functional outcomes and complication rates observed among studies.<sup>2,3</sup> Hence the present study was conducted to evaluate the functional and radiological outcome along with the complications of locking plate fixation of displaced proximal humeral fractures.

### METHODS

This is a prospective observational study to investigate the functional and radiological outcomes of proximal humerus fractures treated with proximal humerus locking plate. The study was conducted at the Orthopedic department, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry between July 2015 to July 2017. The study was approved by the Institute's Ethical committee.

Patients presenting to the emergency services of the Orthopaedic department with shoulder trauma were evaluated with X-rays of the injured shoulder. Computed tomography (CT) scan with 3D reconstruction was used in selected cases where the fracture pattern couldn't be

clearly made out through plain X-rays and also to rule out intraarticular extension and to assess the extent of comminution.

Adult patients with closed displaced two-part, three-part or four-part proximal humerus fractures according to Neer's classification were included in this study.<sup>4</sup> Patients with open fractures, pathological fractures (except osteoporosis), patients with neurovascular deficit and concomitant ipsilateral fractures of the upper limb were excluded from this study.

A total of 23 adult patients were recruited during the study period. All of them were explained about the procedure and informed consent was taken. The patients were operated under general anesthesia. The surgical approach used was either deltopectoral or deltoid splitting as per the operating surgeon.

### ***Deltopectoral approach***

In 19 patients, we used deltopectoral approach for fixing proximal humerus fracture. The patient was in a beach chair position. The skin incision was made following the line of the deltopectoral groove and the cephalic vein was identified and retracted. Proximal humerus fracture site was exposed through deltopectoral interval. Fracture was reduced with the help of either K-wires or ethibond sutures passed through the Osseo-tendinous junctions of the rotator cuff.

The proximal humerus locking plate (Hardik) was applied lateral to the bicipital groove and distal to the tip of the greater tuberosity. The position was checked with image intensifier. Finally, after confirmation of reduction, screws were applied to the plate. Finally, the wound was closed with a suction drain. Data regarding type of anesthesia, surgical approach, the implant and the number of screws used, duration of surgery, blood loss and any intraoperative complications were recorded.

### ***Deltoid split approach***

For four patients, deltoid-split approach was used. Under general anesthesia, the patient was put in a beach chair position. The lateral border of the acromion process was identified and marked. About 6.5 cm inferior to the tip of acromion process, another landmark was marked for the identification of axillary nerve. The skin incision was made over the lateral aspect of the shoulder while deep incision was extended along deltoid raphe between the anterior and middle deltoid fibers. In all patients, the axillary nerve was identified and secured with a loop. Fracture reduction and fixation technique used were same as in deltopectoral approach. The locking plate was slid under the axillary nerve. After confirmation of reduction and proper positioning of the plate, fixation was done and the wound was primarily closed in layers.

Postoperatively, arm sling was given for pain management and temporary immobilization. Prophylactic

intravenous antibiotics were administered for two doses post-surgery. Elbow and wrist active range of motion exercises were commenced initially, while the passive range of motion and pendulum exercises of the shoulder were encouraged as soon as the pain subsided. Active assisted and passive exercises of the shoulder were done during the first three weeks, after which active range of motion of shoulder was started along with muscle strengthening exercises. All postoperative rehabilitation was done under the guidance of an experienced physiotherapist.

The shoulder functions were assessed using standard Constant-Murley score proforma at postoperative six weeks, three months and six months.<sup>5</sup> The protocol mentioned in the Danish version of modified Constant-Murley score was followed to measure individual parameters.<sup>6</sup>

The final outcome was calculated on the basis of the Constant-Murley score which was graded as poor (0-55 points), moderate (56-70), good (71-85), or excellent (86-100).

The radiographic assessment to identify union, malunion, avascular necrosis (AVN) of the humeral head and implant related complications was done at 6 weeks, 3 months and 6-months post-surgery.

*Union:* Fracture union was assessed using standard radiographs. The presence of callus formation in three cortices, bridging osseous trabeculae and cortical continuity were considered as evidence of radiological union.<sup>7</sup>

*Malunion:* It was defined as healing of the fracture with a neck-shaft angle less than 125 degrees (varus) or more than 145 degrees (valgus) on standard AP radiograph of a shoulder.<sup>7</sup>

*Non-union:* It was defined as failure of the union to occur within 6 months post fixation.<sup>8</sup>

*Deep infection:* It was defined as infection deep to the deltopectoral interval.<sup>8</sup>

*AVN of humeral head:* It was diagnosed according to the association research circulation osseous international classification staging system.<sup>9</sup>

### ***Statistical analysis***

Statistical analysis was performed with the means of statistical software SPSS for Windows, version 17 (SPSS, Chicago, IL). The distribution of data on categorical variables such as gender, occupation, mode of injury, comorbidity, Neer's fracture type, limb involved, surgical approach used, Constant-Murley score categories, radiological profile was expressed as frequency and percentage.

The data on discrete/ continuous variables such as age, average time taken for surgery since injury, duration of hospital stay, duration of surgery, intraoperative blood loss, the level of pain, level of activity of daily living, range of motion, strength, Constant-Murley score were expressed as mean with standard deviation 'or' median with range.

The comparison of the continuous variables with the categorical variables mentioned above was analyzed by using Independent Student t-test, Mann-Whitney u test or One-way analysis of variance/Kruskal-Wallis test; whichever was appropriate based on the distribution of data and number of groups. The changes in the

continuous outcome variables over time were analyzed by using repeated measures ANOVA. A p value of less than 0.05 was considered to be statistically significant.

## RESULTS

A total of 23 patients with displaced two-part, three-part and four-part proximal humeral fracture were enrolled into the study. The baseline characteristics of study population was described in Table 1. The overall mean age of the patients was 46±14 years (range 20-78).

The average age of male patients was 40.7±12.8 and female was 57.6±10.5.

**Table 1: Base line characteristics of the study population (n=23).**

	Number	Percentage (%)
<b>Age groups (in years)</b>		
<50	12	52.2
≥50	11	47.8
<b>Sex</b>		
Male	16	69.6
Female	7	30.4
<b>Occupation</b>		
Labourer	15	65.2
Agriculture	3	13.0
Professional	2	8.7
Housewife	2	8.7
Students	1	4.3
<b>Comorbidity</b>		
None	14	60.9
Diabetes mellitus	3	13.0
Hypertension	3	13.0
Other*	2	8.7
Chronic kidney disease	1	4.3
<b>Mechanism of injury</b>		
Road traffic accident	15	65.2
Fall on surface	8	34.8
<b>Limb involved</b>		
Right	13	56.5
Left	10	43.5
<b>Neer's fracture type</b>		
Two-part	12	52.2
Three-part	7	30.4
Four-part	4	17.4
<b>Head-shaft angle</b>		
Normal (125-145)	3	13.0
Varus (<125)	9	39.1
Valgus (>145)	11	47.8
<b>Metaphyseal comminution</b>		
Yes	8	34.8
No	15	65.2

\*Bronchial asthma, coronary artery disease.

**Table 2: Individual parameters of Constant-Murley score at 1.5, 3 and 6 months follow-up.**

	Constant murley score	1.5months Mean±SD	3 months Mean±SD	6 months Mean±SD	df	F value	P value*
<b>Pain</b>	15	8.1±1.1	9.9±1.0	11.8±1.1			
<b>ADL</b>	20	10.2±1.6	13.0±2.2	15.4±1.7			
<b>Range of motion</b>	40	14.4±2.1	25.1±4.7	31.0±5.8			
<b>Strength</b>	25	3.5±0.9	5.8±1.4	7.9±2.5			
<b>Total score</b>	100	36.4±4.5	54.1±8.3	66.0±10.0	2	266.5	0

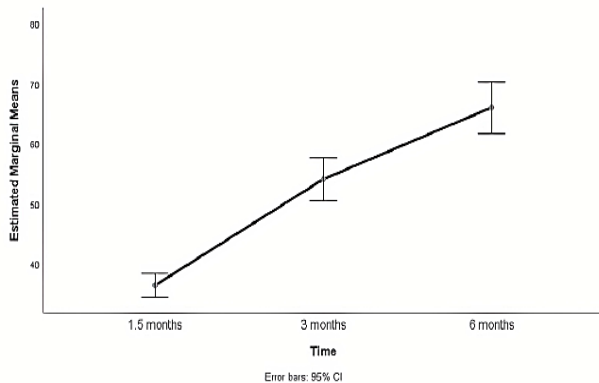
ADL-activity of daily living, \*ANOVA test, df – Degree of freedom.

**Table 3: Influence of Neer’s fracture type on shoulder functional outcome.**

Neer’s fracture type	N	CM score (Mean±SD)	*P value
<b>Two-part fracture (n=12)</b>	12	72.4±8.8	0.002
<b>Three-part fracture (n=7)</b>	7	59.4±6.4	
<b>Four-part fracture (n=4)</b>	4	58.3±2.0	

\*ANOVA test; df-2

The Constant-Murley score achieved at the end of 6 months was 66.0±10.0. The Constant-Murley score significantly (p=0.000) improved over each successive follow-up period with the average improvement of 19 scores between 1<sup>st</sup> and 2<sup>nd</sup> follow-up and around 12 score improvement between 2<sup>nd</sup> and 3<sup>rd</sup> follow-up (Figure 1). We observed improvement in all the individual parameters (pain, activity of daily living, range of motion, strength) of Constant-Murley score at the end of study period (Table 2).

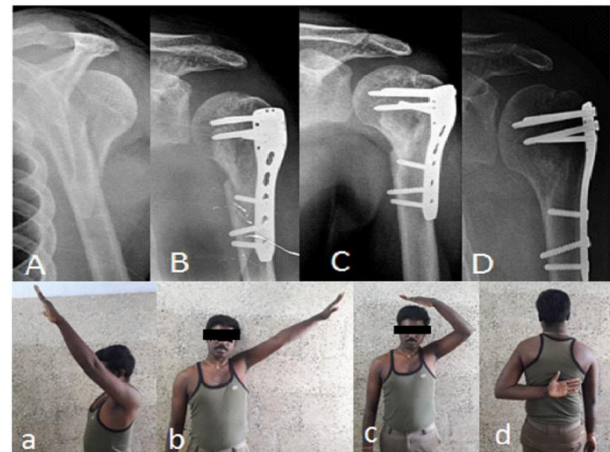


**Figure 1: The mean Constant Murley score at successive follow up.**

Out of 23, 9 patients had good (Figure 2), 10 patients had moderate and only 4 patients had poor functional outcome. None of the patients had excellent outcome.

We found the statistical difference between Neer’s fracture type and functional outcome at 6-months follow-up (Table 3). On post hoc analysis, we found that the functional outcome of two-part proximal humerus fractures significantly differed from three-part and four-part proximal humerus fractures, but we didn’t find any statistically significant difference in functional outcomes

between three-part and four-part proximal humerus fractures.



**Figure 2: Two part proximal humerus fracture in a 25 year old patient treated with open reduction and internal fixation with proximal humerus locking plate. (A) Preoperative, (B) postoperative, (C) 3 months, (D) 6 months follow up X-rays AP view showing different stages of bone healing. Range of motion (a) forward elevation, (b) lateral elevation, (c) external rotation, (d) internal rotation at 6 months follow up is shown (Constant score:82).**

**Radiological outcome**

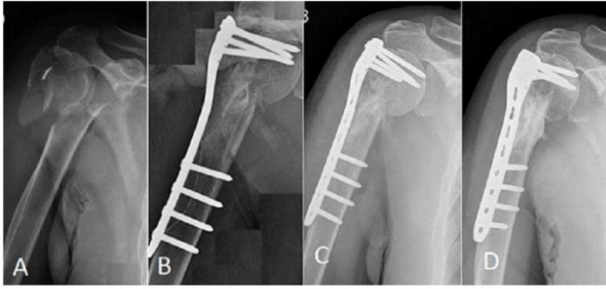
Union: In our study, out of 23 proximal humeral fractures, 22 fractures united at 6 months follow-up.

**Intra-operative complications**

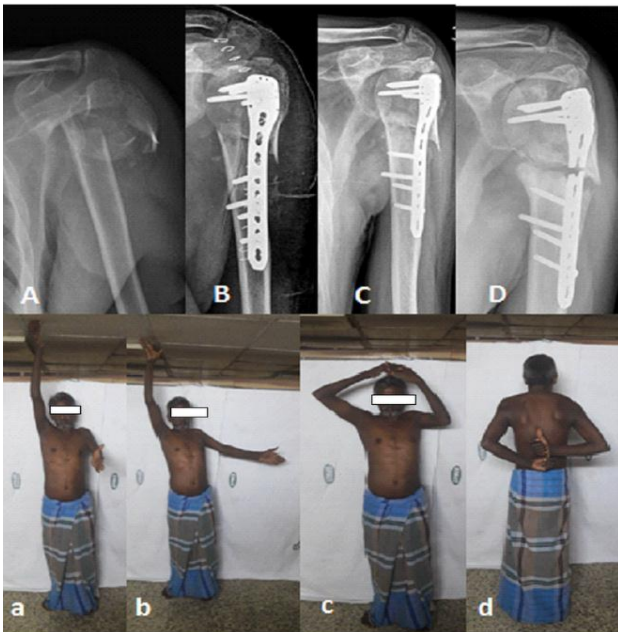
**Metaphyseal comminution**

Intraoperatively, four patients were found to have extensive comminution in the metaphyseal region and

bone loss intraoperatively. Bone cement, fibular strut graft, iliac crest cancellous graft and allograft were used individually in those patients.



**Figure 3: Two part proximal humerus fracture in a 50 year old female treated with proximal humerus locking plate. (A) Preoperative, (B) immediate postoperative, (C) 3 months follow up, (D) 6 months follow up X-ray of the patient in AP view. The fracture was fixed in varus and at the end of 6 months follow up the fracture healed showing varus (head-shaft angle 107 degrees) malunion (Constant-Murley score- 53).**



**Figure 4: X-ray shoulder AP view of three part proximal humerus fracture in a 50 year old male. (A) Preoperative, (B) immediate postoperative, (C) 3 months follow up, (D) 6 months follow up X-ray of the patient in AP view. The implant had broken secondary to nonunion. Range of motion (a) forward elevation, (b) lateral elevation, (c) external rotation, (d) internal rotation at 6 months follow up is shown.(Constant score:48)**

**Post-operative complications**

**Malunion:** Four cases of malunion were reported in our study and all were due to the improper reduction of the

head fragment at the time of surgery. Three cases of varus malunion with head shaft angle of 107, 116 and 95 degrees were found. One case of valgus mal-union was observed in our study with the head-shaft angle of 160 degrees. All are two-part proximal humerus fractures with metaphyseal comminution. Two cases out of these 4 malunited cases had a poor functional outcome (Figure 3) and the other two cases had a good functional outcome.

**Surgical site infection:** Three cases of superficial surgical site infection were reported in the study. No patient had deep infection. All the cases eventually healed with daily cleaning and dressing. For comparison with other studies we didn't analyze superficial surgical site infection as complication as most of the studies reported deep infection as complication.

**Screw penetration into the joint:** Two cases of screw penetration into the joint were found in our study due to the collapse of the head at 6 months follow-up. Both patients had poor functional outcome.

**Nonunion with implant breakage:** One case of implant failure was noticed in our study during follow-up period because of non-union (Figure 4). The patient had poor functional outcome. The patient underwent revision surgery.

**DISCUSSION**

Management of proximal humerus fracture is always a challenge to the treating surgeon. The goal of proximal humeral fracture fixation is to obtain a painless functional shoulder. Locking plate technology is the most recent which has been developed to overcome the difficulties and complications faced by previous fixation methods and it shows promising results in recent studies.<sup>2,3</sup>

In our study, most of the patients had two-part (52.2%) followed by three-part (30.4%) and four-part (17.4%) proximal humerus fractures. This is in accordance with the results of epidemiological studies conducted by Court-Brown et al and Roux et al.<sup>10,11</sup> who stated that the most common displaced fracture pattern was 2 part fractures followed by 3 part and 4 part respectively. But this is in contrast to the findings of Vijayvargiya et al.<sup>7</sup> study on 26 patients where most of the fractures observed are three-part (46.1%) followed by four-part (34.7%) and least number are two-part (19.2%) proximal humerus fractures. Similarly, Erasmo et al observed a higher number of three-part fractures (40), compared to four-part (35) and two-part (2) among a total number of 81 patients with 82 proximal humeral humerus fractures.<sup>12</sup>

In our study, we observed that road traffic accident was the most common mode of injury (65.2%) followed by simple falls (34.8%). This is in contrast to the earlier epidemiological studies which state accidental fall as the most common mode of injury.<sup>10,11</sup> Vijayvargiya et al

study also reported fall (53.8%) as the predominant mode of injury followed by road traffic accidents (46.2%).<sup>7</sup>

Mean duration of surgery in our study was 216 minutes. Mean duration of surgery in the deltopectoral group was 210 minutes and mean duration of surgery in the deltoid-split group was 247 minutes with no significant difference in duration between two surgical approaches ( $p=0.431$ ). This was higher than the operating time noted by other studies.<sup>13-15</sup> Buecking et al reported an average time taken for surgery in deltopectoral approach was 67 minutes whereas in deltoid split approach was 62 minutes whereas Waliulah et al reported 84 minutes for deltopectoral approach and 72 minutes for the deltoid split approach.<sup>14,15</sup> This higher operating time in our study was because of delay in timing of index surgery because of which reduction and fixation of fracture fragments was difficult. Most of the patients present late to our hospital after undergoing initial treatment in a primary care centre or in the form of native bandaging. This is the most common cause for delay in index surgery. Also multiple surgeons were involved in operating these cases, whose training and experience varied.

The average Constant-Murley score observed at the end of 6 months follow-up was 66. The variations in reported Constant-Murley score among different studies attribute to a multitude of reasons like the average age of patients, various follow-up periods and difference in physical characteristics of patients with individual race.<sup>7,12,16-29</sup>

In our study, nine patients (39.1%) had good 10 patients (43.5%) had moderate and only 4 patients (17.4%) had poor functional outcome.

We compared the results of two-part, three-part and four-part fracture types as per Constant score. We found a significant difference in Constant-Murley score among two-part, three-part and four-part proximal humeral fractures (72.4 vs. 59.4 vs. 58.3) analyzed by ANOVA test with a p-value of 0.002. Between patients with 3-part and 4-part fractures, no significant difference was observed in outcomes. These findings are similar to reported by Vijayvargiya et al study (80.8 vs. 71.3 vs. 69.3).<sup>7</sup> This study, like our study, didn't find any significant difference in outcomes between patients with 3-part and 4-part fractures.

In our study, older age group ( $\geq 50$ ) had the statistically significant poor functional outcome with Constant-Murley score of  $61.2 \pm 8.8$  compared to younger age group ( $< 50$ ) which was  $70.4 \pm 9.1$  at 6 months follow-up analyzed by independent t-test p-value of .022. Vijayvargiya et al study also observed similar finding with age group  $< 50$  having significantly ( $p=0.032$ ) higher score than  $> 50$  year age group.<sup>7</sup> However, more recently Koukakis et al published a series of 20 patients with two-three-and four-part fractures and has shown no difference in functional outcome between older age group greater

than 65 years compared to younger age group lesser than 65 years.<sup>16</sup>

We didn't find any statistical difference ( $p=0.957$ ) between the functional outcomes in patients who underwent proximal humerus fracture fixation through deltopectoral or deltoid-splitting approach. In our study, time for the union was 3 to 6 months. All fractures except one united at the end of study period. Vijayvargiya et al study reported mean time to union was 12.3 weeks (9 -15 weeks) in 26 patients studied.<sup>7</sup>

Bone graft or substitute was used in 4 patients to fill the metaphyseal defect at the time of reduction to prevent varus collapse and for augmentation. Bone cement, fibular strut graft, iliac crest cancellous graft, and allograft were used individually in these patients. However, varus malunion occurred in two of these patients due to improper reduction at the time of surgery. These fractures were associated with extensive metaphyseal comminution.

Associated comorbidities were found in nine patients, hypertension and diabetes (13% each) being the most common. Among the two diabetic patients, one had superficial surgical site wound infection and delayed wound healing. But no co-morbidity had influenced the outcome.

In our study, complications were observed in 30.4% (7) of the study patients. Four were malunions, 1 broken implant with nonunion, 2 screw penetration into the joint. Three patients with superficial surgical site infection were managed by daily cleaning and dressing without long term complications. No cases of AVN of humeral head or nerve palsy were observed in our study. Complication rates observed across the literature varied from 0 to 40%.<sup>7,12,16-29</sup> The observed complication in the present study was similar to the study conducted by Vijayvargiya et al.<sup>7</sup> In their study, 15.4% (4) patients reported complications including 1 case of surgical site wound infection, 2 cases of malunion and 1 case of screw penetration into the joint. But, in a prospective study by Repetto et al, 7 (36.8%) patients had complications with 4 cases of AVN of the humeral head, 1 case of transient circumflex nerve palsy and 2 cases of sub acromial impingement due to proximally placed implant.<sup>17</sup> This was in contrast to our study where no AVN of the humeral head was reported. This may be due to shorter follow-up period in our study as compared to 37 months follow-up period in their study. The limitation of our study was the smaller sample size and the short term follow up. Hence complications like AVN of humeral head were not identified.

To conclude, our study had good/moderate functional outcomes among 83% of patients with two-part, three-part and four-part proximal humerus fracture treated with locking plate and observed complication rate among 30% participants We are of the opinion that proximal humerus

locking plate is an effective system for stabilizing two-part, three-part and four-part proximal humerus fractures but one should be wary of potential complications. Additional studies with larger cohorts and longer follow-ups are necessary to better define the appropriate indications and expected outcomes of this technology.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the institutional ethics committee of JIPMER*

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**Cite this article as:** Rathod A, Balaji G, Patro D. Locking Plate for displaced proximal humerus fractures-outcomes and complications: a prospective study. *Int J Res Orthop* 2019;5:1178-85.